Numerical Propulsion System Simulation and the Aviation Safety Program on the Information Power Grid

Gregory Follen, Isaac Lopez,
Desheng Zhang, Robert Griffin

IPG Workshop 2001

Presentation Outline

- **Section 1** : Numerical Propulsion System Simulation
- **Section 2** : Aviation Safety Program
- **Section 3** : Batch Job Processing on the Information Power Grid
- **Section 4** : Future Directions

Section 1

NPSS

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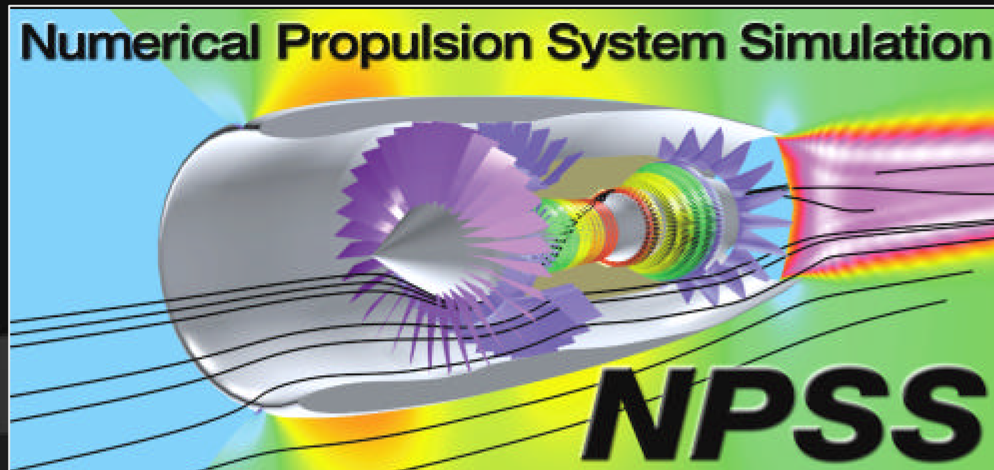


Validated Models

- Fluids
- Heat transfer
- Combustion
- Structures
- Materials
- Controls
- Manufacturing
- Economics

Integrated Interdisciplinary Analysis and Design of Propulsion Systems

Information Technology

- Parallel processing
- Object-oriented architecture
- Expert systems
- Interactive 3-D graphics
- High-speed networks
- Database management systems

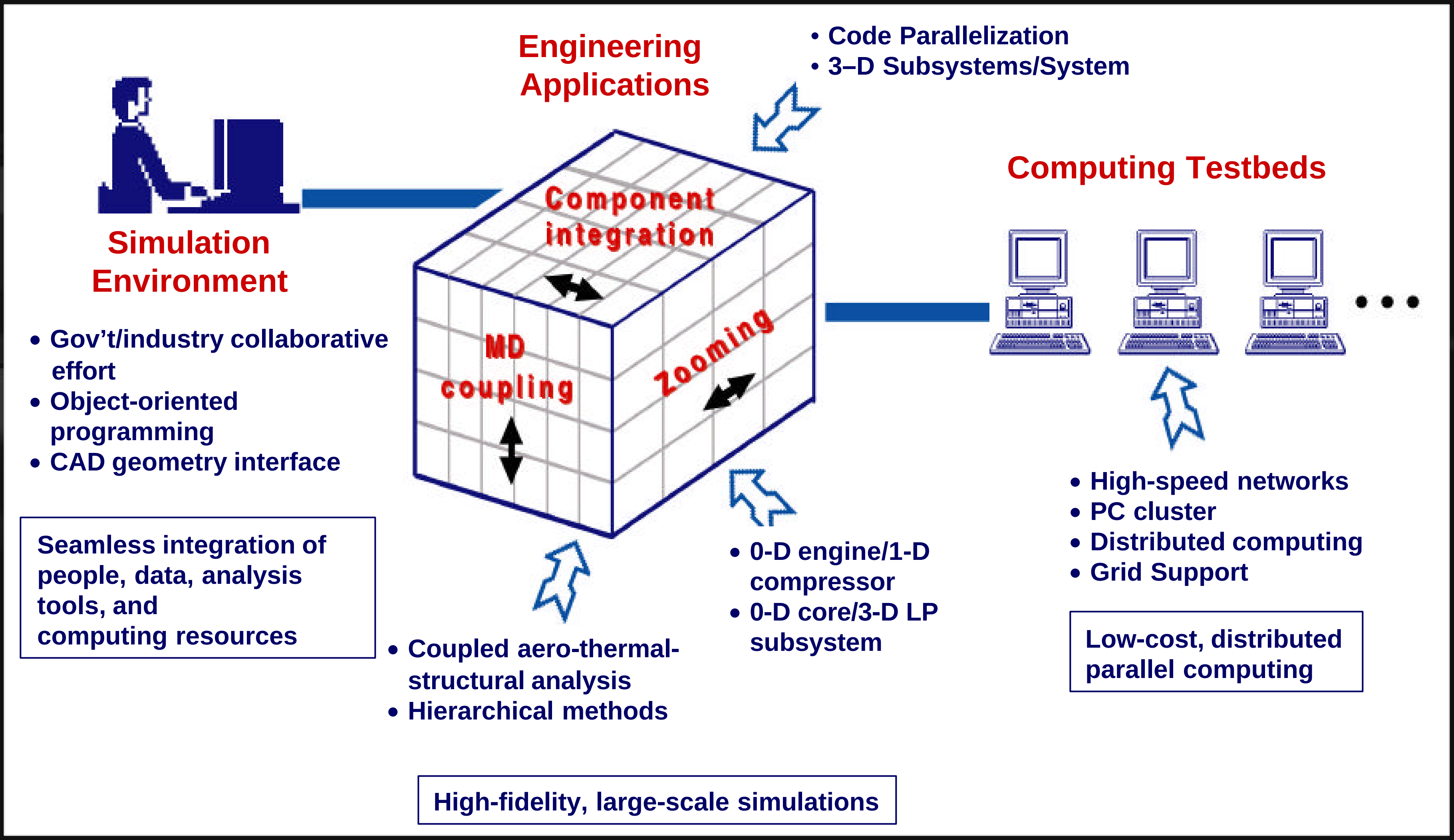
Rapid Affordable Computation of

- Performance
- Stability
- Cost
- Life

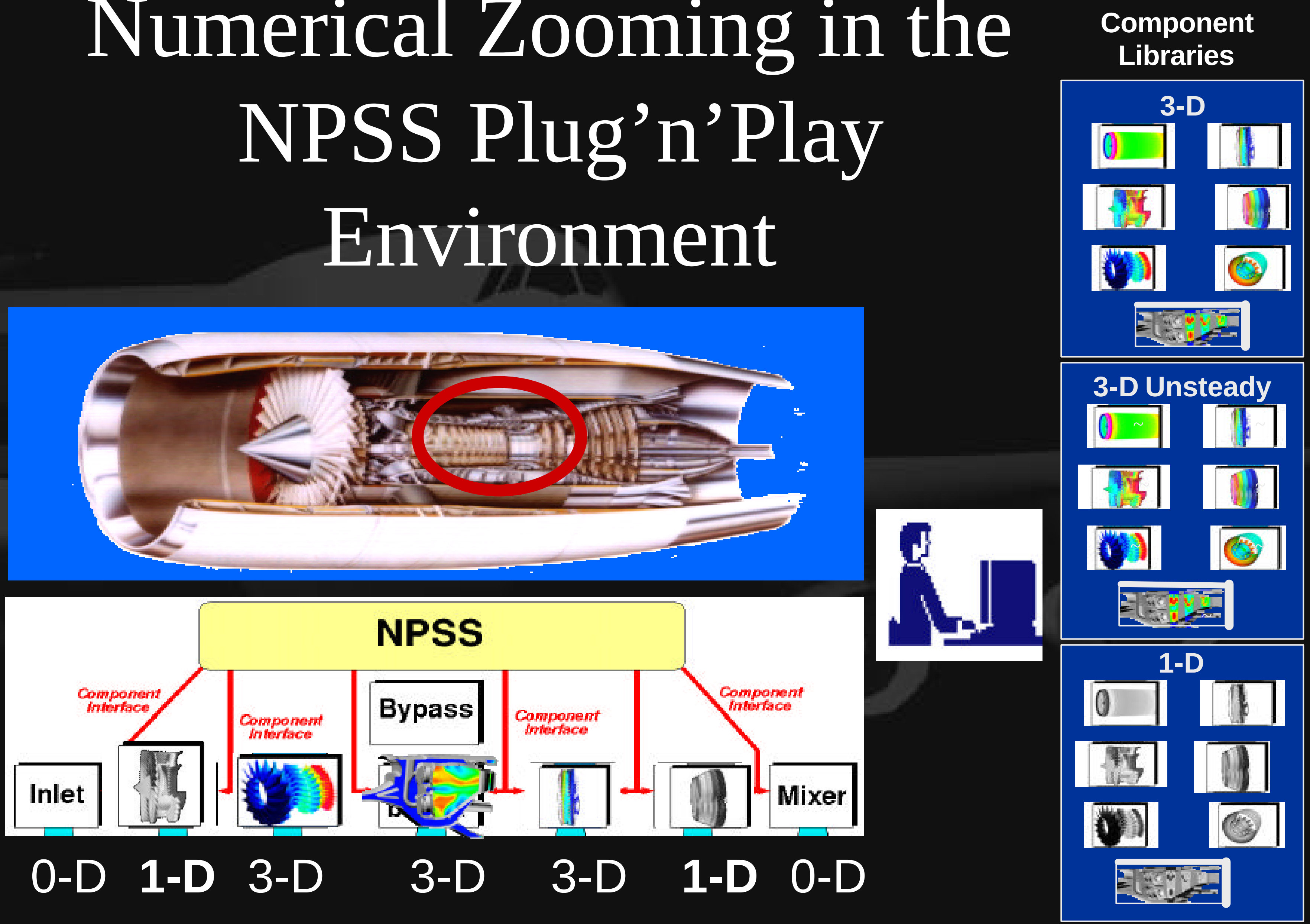
A Numerical Test Cell for Aerospace Propulsion Systems

Benefit to Aerospace: 30% to 50% Reduction in Development Time and Cost!!!

NPSS – Major Elements



Numerical Zooming in the NPSS Plug'n'Play Environment



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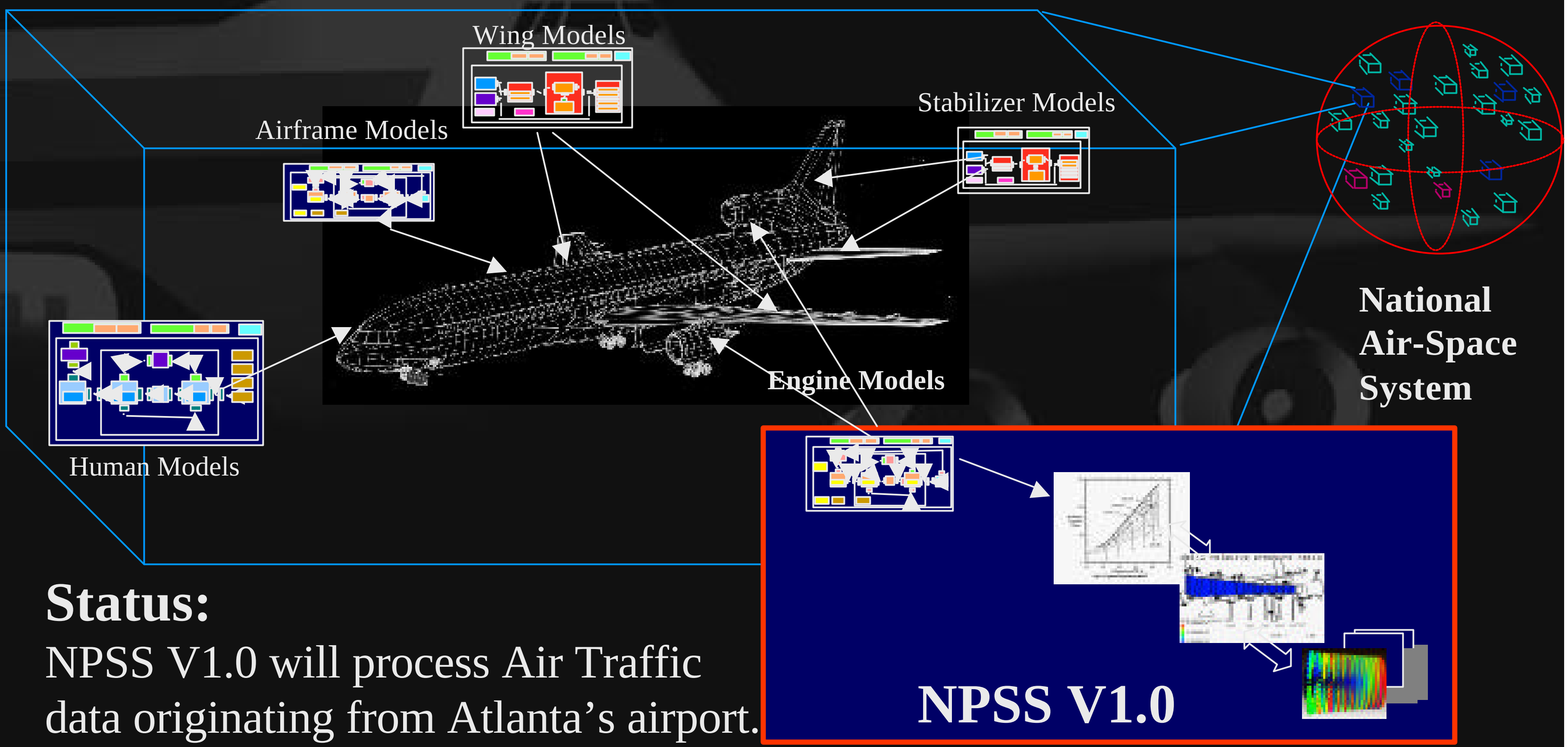
Section 2

AvSP

Aviation Safety Program

- Overall objective of the NASA Aviation Safety Program Goal is to "Develop and demonstrate technologies that contribute to a reduction in the aviation fatal accident rate by a factor of 5 by year 2007 and by a factor of 10 by year 2022".
- Presentation details part of a collaborative effort between NASA Glenn and NASA Ames Research Centers. Contributors from NASA Ames include Bill McDermott and Jorge Bardina

AvSP : Aviation System Monitoring and Modeling



Status:

NPSS V1.0 will process Air Traffic data originating from Atlanta's airport.

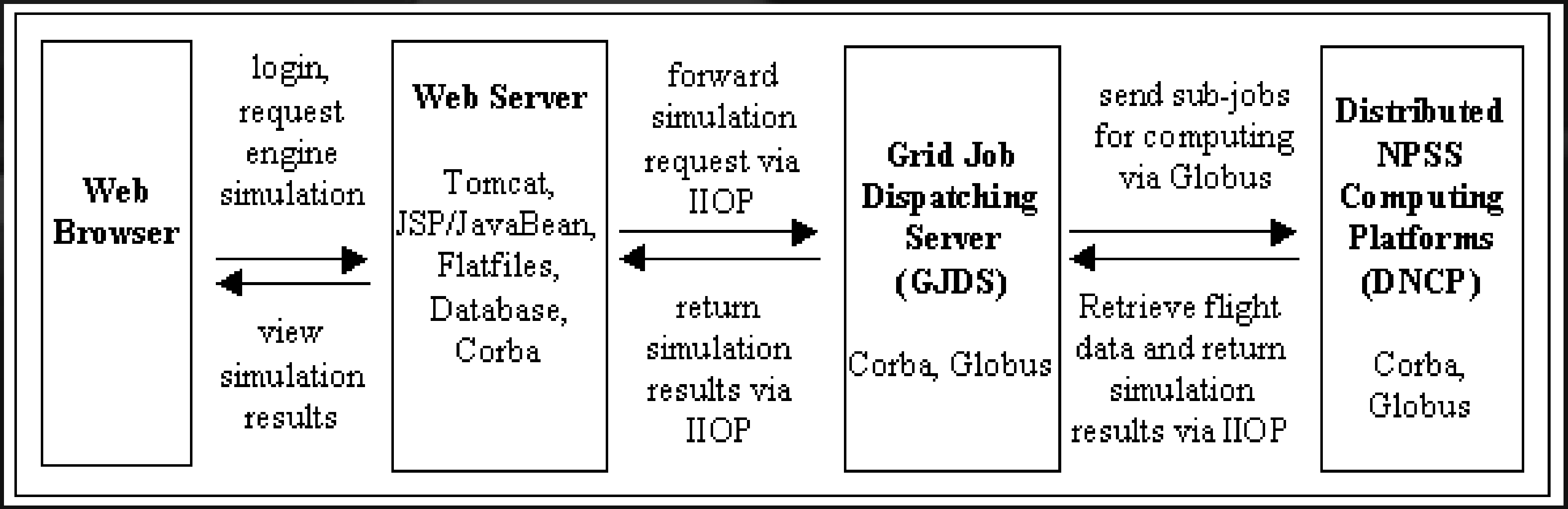
AvSP Short Term Goals

- Use NPSS as a tool for analyzing flight data obtained from commercial airline flights to discover performance and provide risk assessments of the engines on typical flight profiles with the National Aviation System.

Stepwise:

- Agree on a file format for flight data that can be used with NPSS.
- Create means by which the flight data may become available for processing during NPSS executions.
- Locate computing resources on which NPSS may be executed.

Interactive Job Submission



Incorporated Technologies

- Core Technologies include:
  - Java Server Page (JSP) / Java Beans
  - Common Object Request Broker Architecture (CORBA)
  - Information Power Grid (IPG/Globus)
  - Numerical Propulsion System Simulation (NPSS) with 1-D Zooming

Performance of Prototype

Data Input *KB / Flight*	33
Data Output *KB / Flight*	35 (0-D) 140 (1-D)
IPG Machine Count *1 Process / Machine*	3 *Rogallo (LaRC), Turing (ARC), Sharp (GRC)*
Process Rate *Flight / Minute*	1

Evolution

- *Flight data for a single day represented approximately 2000 flights.*
- Interactive Job Submissions weren’t appropriate for the amount of data that could be received on a daily basis. We needed to Automate the process.
- A method for processing Batches of data is required.

Batch Processing Requirements

- Data
- Engine Simulation
- High-End Computing Resources
- A More Sophisticated Job Scheduler

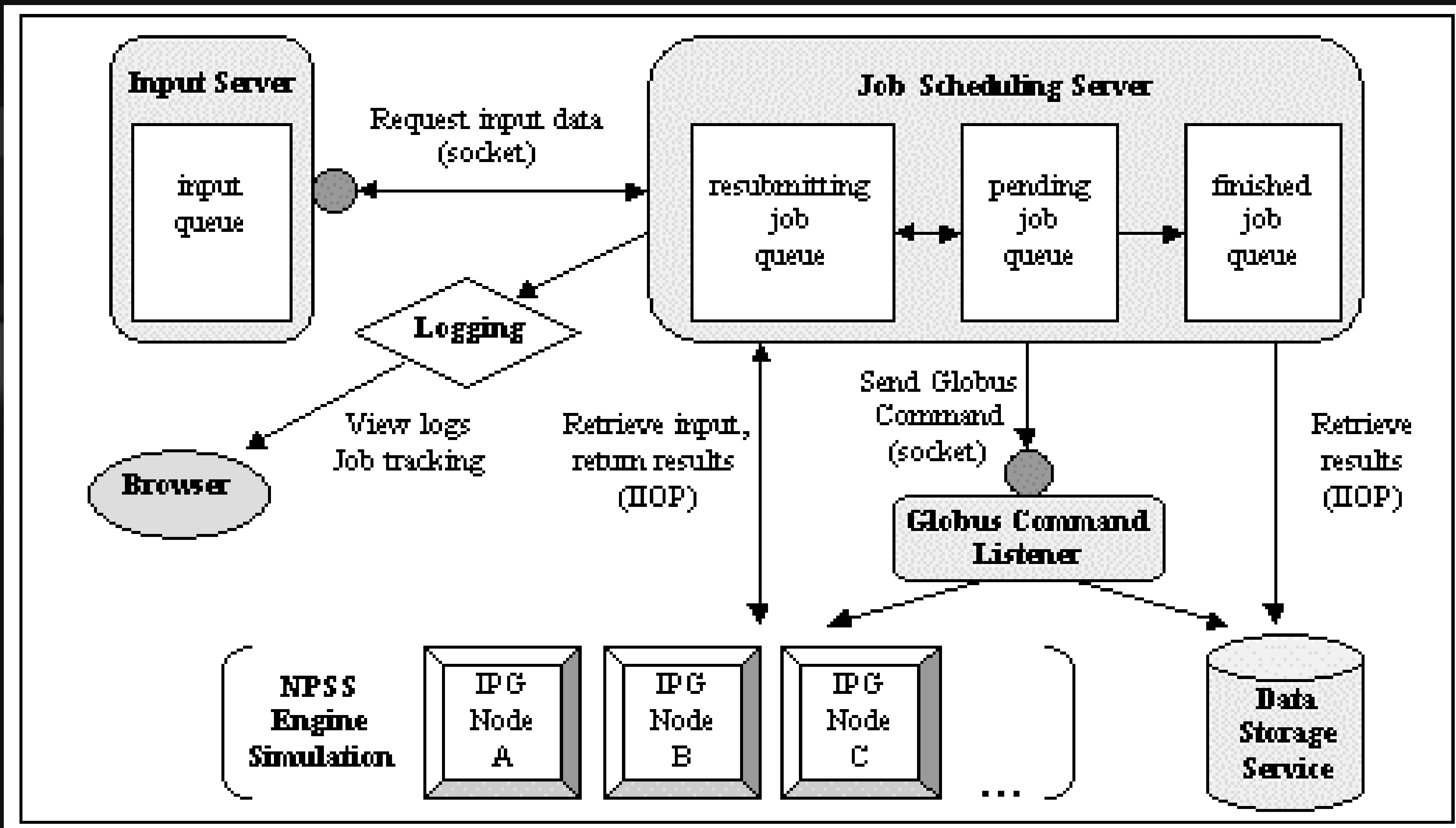
Section 3

Batch Job Processing on the Information Power Grid

Features of Job Scheduler

- Multithreaded Architecture
- Job Status divided into a set of Fixed States
  - Submitted, Old, Bad, Resubmitted, Waiting, Finished, and Stored
- Resubmission of Failed Jobs to Alternate Hosts (Quality of Service)
- Logging of Job Queue Activity
- Load Balancing

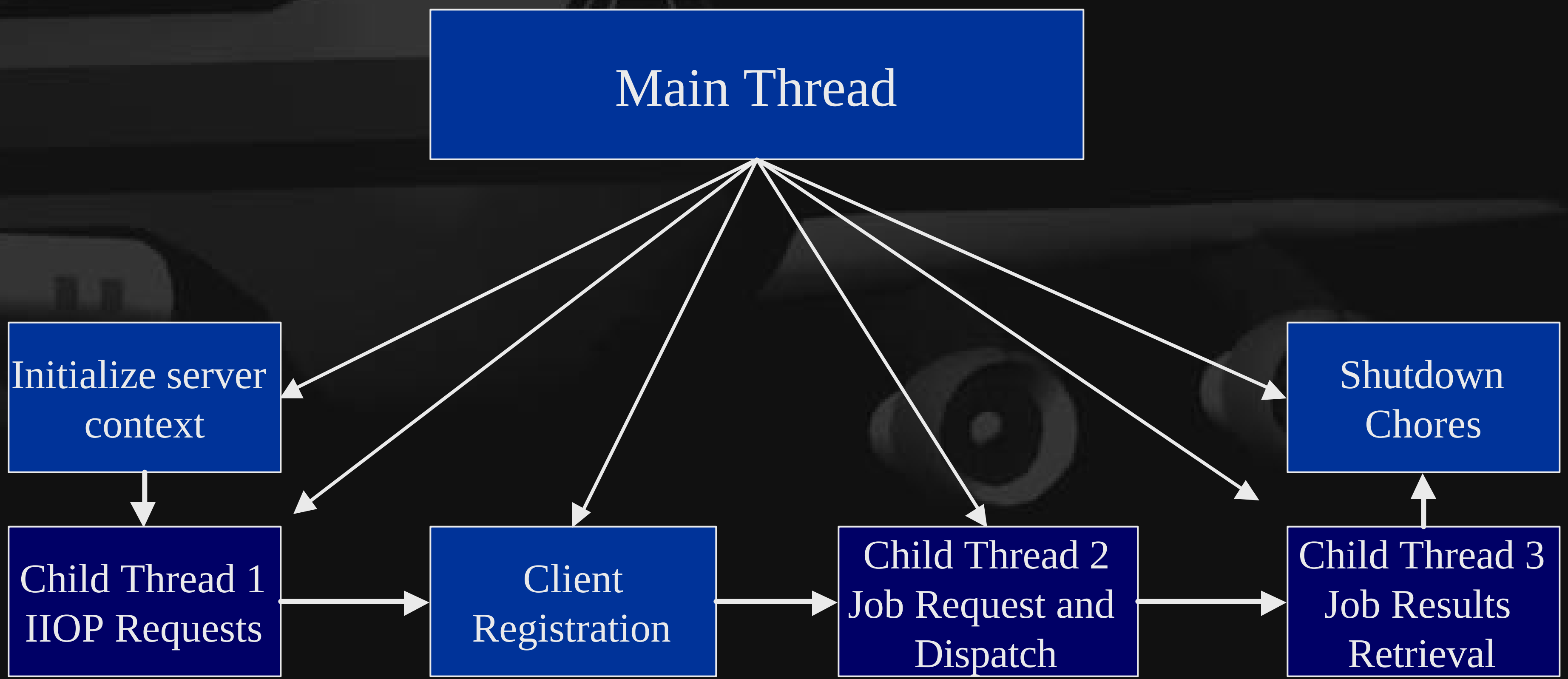
AvSP Job Scheduler Architecture



XML Configuration Parameters

Parameter name	Parameter function
root, dns	Server root of file structure, server DNS name
gcl_port	Globus Command Listener listening port
is_dns, is_port	Input Server DNS name and listening port
initial_wait	Initial time-out interval for CORBA clients registration
max_job_get, max_job_return, job_get_frequency, job_return_frequency	Job fetching and returning policies
max_queue_time	Maximal residency time a job waiting in pending job queue
max_resubmit_queue_size	Maximal resubmit job queue size
job_track_size	The number of recent jobs to be tracked
dispatchlogfile, retrievelogfile, returnlogfile, storagelogfile, exceptionlogfile, jobstatusfile, jobtrackfile, pendingjobqueuefile, finishedjobqueuefile	Log files for job submission, input retrieval, job results return, job results storage, job exception, job status, job tracking, pending/resubmitting job queue, finished job queue
nodeset	A set of IPG computing nodes (each has parameters of id, dns, root, err_status, load, last_access_time and pending_jobs)
datastorageservice	Data Storage Service with parameters of id, dns, root and err_status

Event Sequence in Job Scheduler



CORBA Interface to Job Scheduler Service

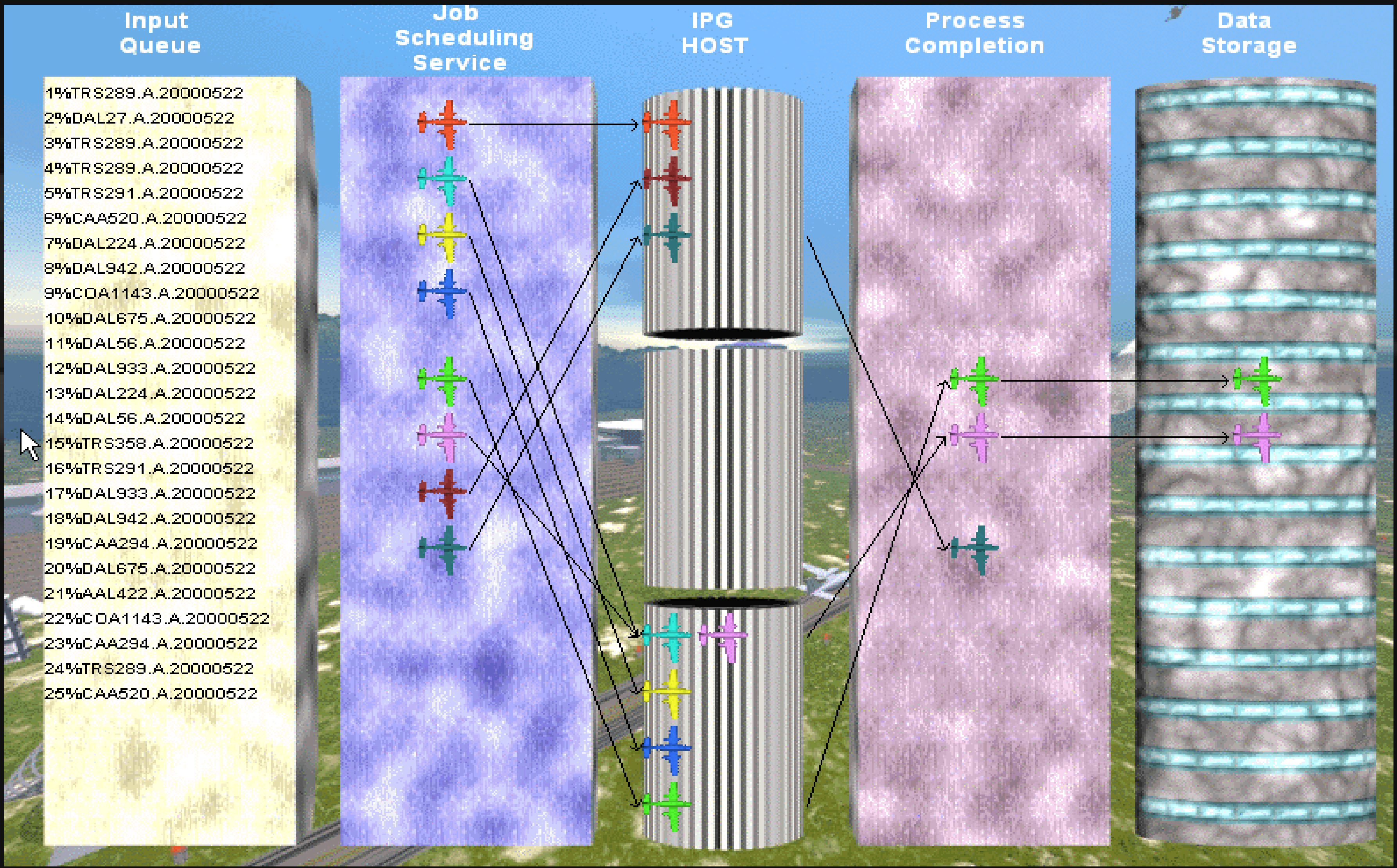
```
typedef sequence<string> SimResult;
typedef sequence<string> FlightDat;
typedef sequence<string> JobQueue;

interface avsp {
        void getinput(in string flight_id, out FlightDat flight_dat);
        void simresult(in string flight_id, in SimResult rslt, in string node_id);
        void getoutput(in string flight_id, out SimResult rslt);

        void getPendingJobQueue(out JobQueue queue);
        void getFinishedJobQueue(out JobQueue queue);
        void getResubmitJobQueue(out JobQueue queue);

        void registerGridNode(in string node_id);
        void registerDataStorageService();
};
```

Job-Tracking Applet



Scheduler Performance

The performance depends on number of nodes, node load, Globus, and server configuration.

Number of Nodes 2

Server Parameters:	maxjobget	5 flights
	jobgetfrequency	every 40 seconds
	load	1.0 for each node

Run Case#1:

NPSS Model	NPSS 0D, one engine/flight
Performance	280 flights/53 minutes (2000 flights/6.30 hours)

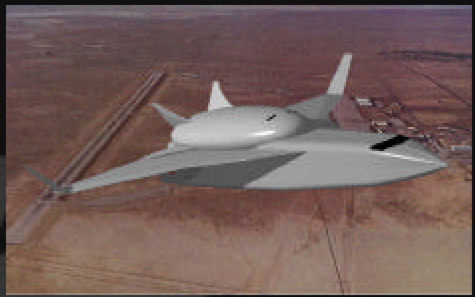
Run Case #2:

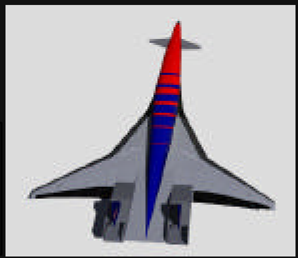
NPSS Model	NPSS 0D plus CSPAN 1D zooming, one engine/flight
Performance	680 flights/152 minutes (2000 flights/7.45 hours)

Section 4

Future Directions

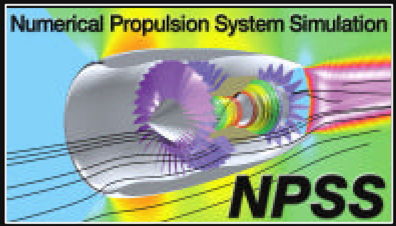
Computational Intelligence for Advanced Aerospace Power and Propulsion Systems





2000 2001 2002 2003 2004 2005 2006

<u>NPSS Version 1</u>
Software Architecture Implemented for 0-Dimensional Aircraft Engine System



<u>CIAPP Version 1.0</u>
Visual Based Syntax Layer, 1-Dimensional Zooming, Deploy over IPG

<u>CIAPP V2.0</u>
3-Dimensional, Aero/Thermal Full Engine Simulation, Knowledge Mgmt, IPG

<u>CIAPP V3.0</u>
3-Dimensional, Unsteady, Aero/Thermal/Structural Full Propulsion System Simulation, Wireless sensors, Distributed Controls, Celestial-Terrestrial IPG

Computational Intelligence for Aerospace Power and Propulsion Systems

- Revolutionary Engineering Environment
  - Multi-fidelity, multi-disciplinary plug 'n play design
  - Integration of people, data, tools and computing platforms throughout the life cycle
  - Measurement data processing
  - Continuous knowledge capture
  - Immersive visualization
  - Quantifiable risk assessment
- Intelligent Engine
  - Embedded, wireless sensors
  - Distributed controls
  - Data extraction and synthesis
  - Knowledge management architecture
- Autonomous Decision Making in Design, Test and Operation